

# MODIS MOD07 Temperature, Moisture, and Ozone products: Recent Updates and Validation

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The MODIS MOD07 algorithm (Seemann et al., 2003) uses 11 IR channels (25, 27-36) to retrieve atmospheric profiles of temperature and moisture, total precipitable water vapor (TPW), total ozone, lifted index, and surface skin temperature. The retrieval algorithm uses clear-sky radiances measured by MODIS over land and ocean for both day and night. The algorithm employs a statistical retrieval algorithm. The synthetic regression coefficients for the statistical retrieval are derived using a fast radiative transfer model with atmospheric characteristics taken from a dataset of 15,704 global profiles of atmospheric temperature, moisture, and ozone profiles. Radiative transfer calculations provide a temperature-moisture-ozone profile / MODIS radiance pair for use in the statistical regression analysis.

Routine comparisons of the MOD07 products are made with ground- and space-based instruments, including GOES, AMSU, TOMS, radiosonde, MWR, and GPS. Comparisons of the MODIS MOD07 IR TPW and the UW-Madison IMAPP Near-IR TPW product are also presented in this poster. Additional MOD07 Terra and Aqua near-real time direct broadcast products (including temperature, lifted index, ozone, and mixing ratio) and comparisons can be found at the web site: <http://cimss.ssec.wisc.edu/modis/mod07>.

A paper detailing a new "baseline fit" database of land surface emissivity and its application to training data profiles used in MOD07 retrievals, including impacts of the emissivity on retrieval validation was submitted to the JAMC:

**Seemann, S.W., E. E. Borbas, R.O. Knuteson, E. Weisz, G.R. Stephenson, J. Li, H.-L. Huang: A global infrared surface emissivity database for clear sky atmospheric sounding retrievals from satellite-based radiance measurements, submitted September 2006**

## Operational MODIS MOD07 collection 5.2 updates

Updated Terra regression coefficients, MODIS\_REGCOEF\_col5.2.terra

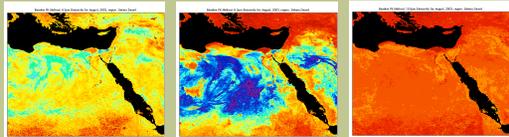
1. Regression coefficients are now computed from an updated set of training data profiles. There are now 15704 profiles (formerly 12245). The increase comes from adding new ozonesondes and increasing the saturation threshold to 99%. This allows all profiles with RH < 99% at all levels to be considered clear. Previously this criteria was 95% but results with 99% were found to be better.

Number of profiles: NOAA88: 6137, TIGR-3: 1387, Radiosonde: 570, Ozonesonde: 1595, ECMWF: 6015

New forward model the prototype-CRTM is used to compute synthetic radiances instead of PFAAST.

2. New emissivity derived from the UW-Madison global gridded IR emissivity dataset is assigned to the profiles.

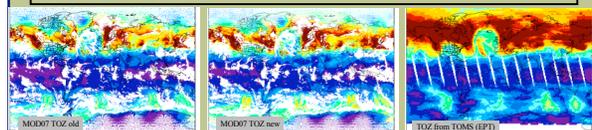
A high spatial and moderate spectral resolution global database of land surface emissivity was developed using a procedure termed the baseline fit method which adjusts a baseline emissivity spectrum to the MODIS MOD11 land surface emissivity measurements according to a series of fitting rules (Seemann et al., submitted 2006). The baseline spectrum as well as the fitting procedure was derived with the use of high spectral laboratory measurements of surface emissivity for a range of materials present on the earth's surface. The database has been derived for 2003-2005 and is available through the website, <http://cimss.ssec.wisc.edu/emis>.



Surface emissivity derived from the baseline fit approach for August 2003 in the Eastern Sahara Desert region. Emissivity is shown for three wavelengths 4.3 mm (left), 8.3 mm (middle), and 10.8 mm (right). The Nile River can be seen curving south from its delta, as identified by the higher emissivity characteristic of water.

### MOD07 statistics compared with MWR for the SGP site

1) New MOD07_v5.2		2) Old MOD07_v5	
Bias	RMS	Bias	RMS
All cases: -0.09mm (-1.03)	2.49mm (2.54)	All cases: 0.59mm (0.62)	2.87mm (2.57)
Dry cases: -0.68mm (-1.43)	1.07mm (1.42)	Dry cases: -0.08mm (0.33)	1.8 mm (2.52)
Wet cases: 1.12mm (0.23)	3.22mm (2.74)	Wet cases: 2.87mm (1.61)	4.15 mm (3.30)



Global comparison of MOD07 Total Ozone (dob) with TOMS (EPT), day & night passes averaged for a summer case Aug 1, 2005



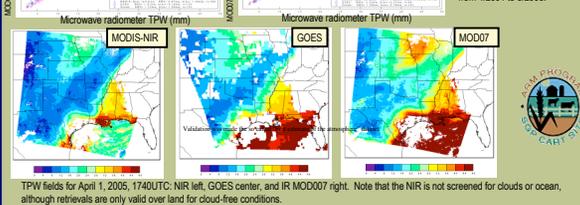
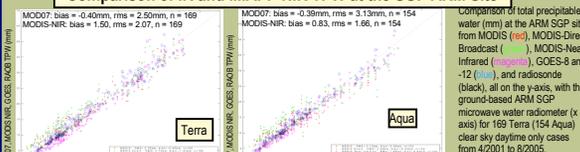
Granule comparison of MOD07 TPW (mm) with GOES for 2003159\_1635

UTC

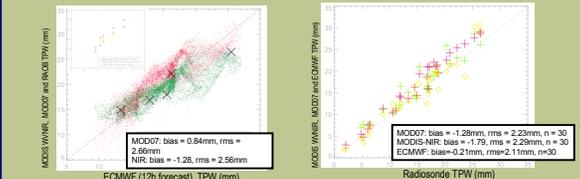
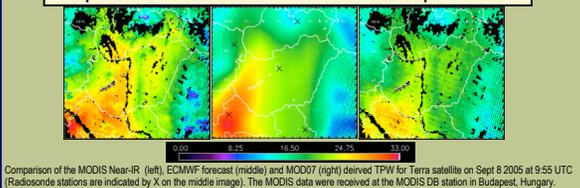
## UW-Madison direct broadcast (IMAPP) Near-IR TPW

The UW-Madison IMAPP processing of the MODIS Near IR TPW products employs the method of P. Albert et al. The IMAPP algorithm was used to generate the products for this comparison. The algorithm uses a differential absorption technique from reflected solar radiation by atmospheric water vapor. The three water near IR vapor absorption bands (900-950 nm, 17-19) and 2 adjacent window channels are used. The near IR TPW algorithm retrieves TPW only during daytime over land for cloud free pixels, however the algorithm runs all pixels so ocean and cloudy scenes must be disregarded. More information on the UW-Madison direct broadcast receiving and processing system, including data access and images can be found at: <http://cimss.ssec.wisc.edu/~gumley/IMAPP> and <http://eosdb.ssec.wisc.edu/modisdirect>.

### Comparison of IR and IMAPP NIR TPW at the SGP ARM Site



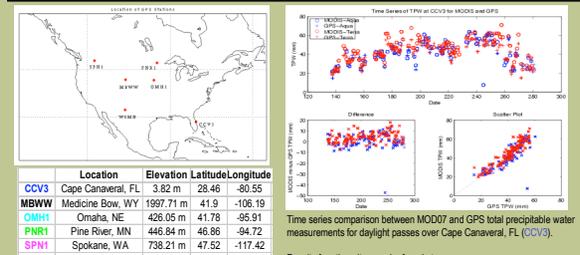
### Comparison of IR and IMAPP NIR TPW over the Carpathian Basin



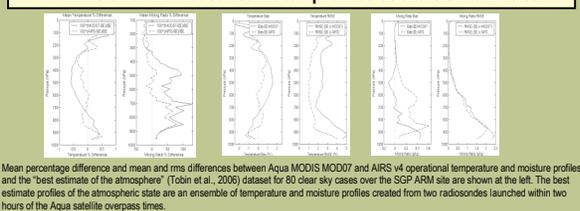
Comparison of TPW from MOD07 (red), Near-IR WV (green), and radiosonde (black crosses) with the ECMWF 00+12h forecast for September 8, 2005, 9:55 UTC

The comparisons of MODIS Near-IR, MOD07 TPW data with ECMWF, ROAB and MWR TPW showed that Near-IR TPW is more accurate than the IR TPW at the SGP ARM site over land, with an rms compared with the SGP MWR for NIR TPW of 2.0mm, and for IR of 2.5mm (Terra satellite) and, NIR rms of 1.6mm and IR rms 3mm (Aqua satellite). Over the Carpathian Basin, the NIR and IR TPW algorithms had approximately the same RMS when compared with radiosonde (2.3mm) and ECMWF (2.6mm), although the NIR algorithm showed a larger bias. The Near-IR products are available only over land and day time; the MOD07 products are available all day and night over land and sea.

## Comparison of MOD07 IR TPW with observations at GPS sites



## Comparison of MOD07 temperature and moisture profiles with AIRS and the "best estimate" profiles at the SGP cart site



## Future Plans and Updates for Collection 6:

1. Investigate the dry bias in Aqua TPW and make adjustments to improve.
2. Perform a more thorough evaluation of the ozone product through intercomparisons with TOMS and AIRS and make adjustments to algorithm.
3. Evaluate the current radiance bias adjustments and make updates.
4. Add ozone profiles instead of just TOZ.
5. Assess the TPW Low and TPW High products and possibly change the levels of integration to make them more useful.
6. Improve QA/QC flags and screening for bad input MOD02L1B data.
7. Examine the MOD07 L3 products for consistency with other long term datasets (NVAP).
8. Perform an experimental combined retrieval with AIRS.
9. Making Aqua and Terra DAAC end uniform.

## Conclusions:

- A new surface emissivity was included in the training data applied to MOD07 in the v5.2 update.
- With the v5.2 update, RMSE for MOD07 TPW retrieved at the ARM SGP site and MWR was reduced from 2.87mm to 2.49mm for 313 clear sky cases between April 2001 and August 2005. Overall bias was reduced from 0.98mm to -0.04mm (positive bias indicates MOD07 is drier than MWR). Bias for wet cases with TPW > 17mm was reduced from 2.87 to 1.12mm, however bias for dry cases increased from -0.08 to -0.68mm.
- Comparisons of IMAPP NIR, MOD07 TPW data with ECMWF, ROAB and MWR TPW were made at the SGP ARM site over the Carpathian Basin.

## References:

Albert, P., Benzart, R., Preusker, R., Leinweber, R., Fischer, J.: 2005, 'Remote Sensing of Atmospheric Water Vapor Using the Moderate Resolution Imaging Spectroradiometer', *Journal of Atmospheric and Oceanic Technology*, Vol. 22, no. 3, pp. 309-314.

Seemann, S.W., J. Li, W.P. Menzel, L.E. Gumley, 2003, 'Operational Retrieval of Atmospheric Temperature, Moisture, and Ozone from MODIS Infrared Radiances', *Journal of Applied Meteorology*, Vol. 42, No. 8, pp. 1072-1091.

Seemann, S.W., E.E. Borbas, R.O. Knuteson, E. Weisz, G.R. Stephenson, J. Li, H.-L. Huang: A global infrared surface emissivity database for clear sky atmospheric sounding retrievals from satellite-based radiance measurements, (submitted to *Journal of Appl. Meteor. and Climatology*, September 2006).

Huang, H.-L. et al., 2004: International MODIS and AIRS Processing Package (IMAPP): A direct broadcast software package for the NASA Earth Observing System. *Bull. Of the American Met. Soc.* 85, No. 2, 159-161.

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**Acknowledgments:** This work was supported by NASA (NNG04H239C).